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Design of Direct-Drive Wind Energy System

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Abstract--**The aim of this work is to discuss a novel configuration of a wind Turbine Generator System (WTGS) equipped with a Variable Speed Generator. Nowadays, doubly- fed induction generators are being widely used on WTGS, although synchronous generators are being extensively utilized too. There are different types of synchronous generators, but the multi-pole Permanent Magnet Synchronous Generator (PMSG) is selected for this prototype. It offers better performance due to higher efficiency and requires less maintenance since it does not have rotor current and can be used without a gearbox, which also implies a reduction of the weight of the nacelle and a reduction of costs. Paper discusses a new method for design of Small scale Wind Turbines. It uses Permanent Magnet Synchronous Generator (PMSG) in a direct-driven topology. PMSGs are preferable for Wind Energy Systems as per this research, where input power is always fluctuating like wind energy. A very unique configuration of Generator design has been chosen amongst various configurations. This configuration along with Vertical Axis and Direct Driven topology makes the project wind turbine very efficient. This simple prototype which costs less than 250 $ is capable of reaching 6.7% of Betz's limit.**

I. DATA

Data discusses a novel method for design of Wind Turbines. It uses Permanent Magnet Synchronous Generator (PMSG) in a direct-driven topology. PMSGs are preferable for Wind Energy Systems where input power is always fluctuating. Simpler Blade Design with improved aerodynamic efficiency as compared to Horizontal Axis Wind Turbines. Induction Generators are very common and have been used for decades but they require separate source for excitation. PMSG is self-excited and no external power required.

Experimental Design, Materials, and Methods

Results were taken on different air speed using oscilloscope for voltage wave form and AC ammeter for deliverable current of generator. Blower type Air Gun has been used to mimic blowing wind. Tachometer available in the campus has been used for measuring rpm of the rotor at different wind speeds.

Voltage measurements: Figure 1 shows the voltage measurements using oscilloscope. It can be seen the voltage is varying with respect to the time and it depends on the air flow in the environment.

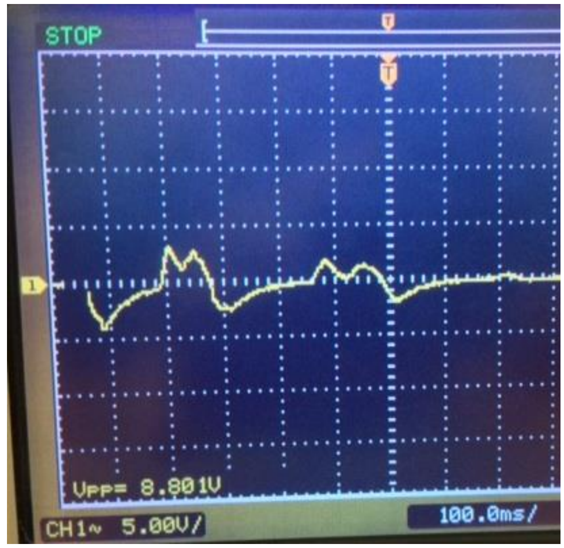

Figure 1: Measurement setup

Table1: Specifications of the system

Subject area	*Electrical Engineering*
More specific subject area	*Machine designing; Renewable Energy*
Type of data	*Text, figures, tables*
How data was acquired	*Oscilloscope, tachometer, multimeter, wattmeter*
Data format	*Filtered*
Experimental factors	*Air gun to mimic wind speed; knowledge of wind speed used in calculation of Tip-Speed-Ratio*
Experimental features	*Oscilloscope was used to measure voltage across generator. Battery was charged and short circuit current was measured across armature using AC ammeter.*
Data source location	*Power Lab and Electric Machine Lab at COMSATS university, Islamabad, Pakistan*
Data accessibility	*Not yet in public repository*
Related research article	*Modeling of a Variable Speed Wind Turbine with a Permanent Magnet Synchronous Generator*

Table 1: Analysis of air speed

Air speed(Blower)	RPM	Voltage(V)
9 m/s	300	28
4.7 m/s	150	13.8
2.1 m/s	70	8

- Measurement of Short circuit currents:

Battery has been used for charging which draws current and ammeter is connected in series to measure maximum deliverable current of generator. Then Short Circuit Current has been measured at output terminal of generators using AC ammeter directly between the terminals.
Figure shows the maximum current draw from the generator output.

Figure 2:

Table 2:

Air Speed (Blower)	RPM	Current I_L
9 m/s	300	0.4
7.6 m/s	240	0.2
6.2 m/s	200	0.16
3.9 m/s	125	0.1

- Maximum Deliverable output Power:

Power output of the Generator (main generator for power generation) is calculated using the formula :
$P_{out} = V_{rms} \times I_{rms}$
We will consider the maximum rated values for calculating rated power of generator:
$P_{out} = \frac{28}{\sqrt{2}} \times \frac{0.4}{\sqrt{2}}$
$P_{out} = 5.6$ watt

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